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HEART RATE VARIABILITY INDICATORS IN PATIENTS WITH HYPOTHYROIDISM

This article presents results of examined patients with hypothyroidism. The examination was performed using computer diagnosis complex "Omega-M" intended for the analysis of biological rhythms. It is concluded that 85.7± 5.4% of patients with hypothyroidism were indicated with sympathetic predominance of autonomic nervous system (ANS). Analysis has revealed increased tension index indicators in patients with hypothyroidism that indicates on dysfunction of the cardiovascular system.

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Introduction

There is no doubt that neuroendocrine system influence on the development of many diseases effecting the function and trophy of tissues and organs. Various negative factors such as psycho-emotional surges, infections, intoxication, injuries and environmental factors condition development of malfunction in cortical regions of the brain, autonomic nervous system and endocrine organs. These disorders are diagnosed as neurosis, vegetative dystonia, hyper- or hypothyroidism, etc.; and they lead to violations of homeostasis and the development of different syndromes.

Nowadays we can say on the basic elements of pathogenesis of neurosomatic infringements. They include firstly the neurotrophic and neurovascular disorders and, secondly, the excessive or insufficient excretion of hormones. All this leads to significant shifts in homeostasis (violations of protein, carbohydrate, fat, water and electrolyte metabolism, acid-base balance, etc.) and violations of the course of metabolic processes in cells and tissues.

The human organism as the subject of medicine is an open non-linear biological system, developing due to the balanced exchange with the environment, energy and information in the form of "information flows" with the space-time distribution in the internal environment. Information flows affect the formation and synchronization functions that determine the effectiveness of life of the organism as a whole (Golofeevsky, 2001). The unity of the interactions is realized in the process of permanent communication between the levels of self-organization: cellular, organ, and organism. The task of a researcher is to clarify the meaning of information contained in this code through the establishment of correspondence between the elements of its structure and what they mean for the self-organized system (Baevsky, 1989). Information on the status of a biological object lies in the modulation of the body's biorhythms and, primarily, in the change of heart rhythmic activity. Therefore, it can be used to estimate the parameters of autonomic homeostasis - one of the most important indicators of the functional state of organism.

The cardio signals are the most understandable sources for informative and mathematical analysis, they are indicators of adaptive reactions and the state of the autonomic nervous system (Smirnov et al., 2001). It is known that cardiac rhythm and tone of the autonomic nervous system (ANS) allows evaluate satisfactory adaptation of organism, functional strain in coping mechanisms, poor condition of adaptation processes with a decrease in functional reserves, and the failure of adaptation to the depletion of the functional reserves. To evaluate the autonomic nervous system it is recommended to use the heart rate variability, which can qualitatively describe the relation of sympathetic and parasympathetic parts of the nervous system in their influence on the function of the sinus node (Zarubin, 1998; Tulemisova, 2009).

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Information integration within a body relations provides a basis to use many of the biological signals of the body as a manifestation of some reactions; for the integral estimation not only about the state of a particular body, which is the source of the signal, but also about the state of the organism as a whole. It is easy to verify that disadaptation types of the organism may have a connection with the pathogenetic mechanisms of many pathological syndromes and diseases, and not only cardiovascular (Golofeevsky, 2001). Excess thyroid function is manifested by activation of sympathetic nervous system, clinically as tachycardia; while, the reduction of functions, on the contrary, is manifested by bradycardia; the heart rate will depend on the initial autonomic balance and changes in thyroid status (Baevsky et al.,1984; Dicheskul, 2001).

Considering the abovementioned, the study aims to identify violations of the autonomic nervous system in patients with hypothyroidism. 42 patients with hypothyroidism were observed, and the control group comprised 30 people.

The study methods

The study methods included a system of integrated computer research on software and hardware complex of the Omega-M, designed for the analysis of biological rhythms of human emissions of elektrokardiosignal in wide frequency band, allowing determining the level of reserves and the cardiovascular system, autonomic and central regulation. The method is based on the new information technology of Heart Rate Variability (HRV) analysis - fractal neurodynamics [Smirnov, 1999].

The index of vegetative balance (IVB) indicates the ratio between the activity of sympathetic and parasympathetic parts of the autonomic nervous system, with normative values from 35 to 145. Regulatory processes adequacy index (RPAI) reflects the correspondence between the parasympathetic activity of the autonomic nervous system and leading level of functioning sinus node, normally from 15 to 50. Vegetative rhythm index (VRI) gives an indication of vegetative balance to assess the activity of the autonomous circuit regulation. The higher the activity, that is the smaller the value of the VRI, the greater the autonomic balance is shifted towards predominance of parasympathetic autonomic nervous system (the rate is 0.25 – 0.6). Tension index (TI) of the regulatory systems reflects the degree of centralization of control heart rate and characterizes the activity of the mechanisms of sympathetic regulation (normal 10-100). The TI is extremely sensitive to increasing of the tone of the sympathetic nervous system. This index is computed on the grounds of analysis of the distribution graphic of cardio schedules - variation pulsogram. Activation of the central circuit, increasing of sympathetic regulation during mental or physical stress are manifested in rate stabilization, decreasing of durations spread of cardio-intervals, increasing of the number of same type duration intervals (Baevsky et al., 2000). Small load (physical or emotional) increases TI up to 1.5-2 times. At heavy loads it grows by 5-10 times; TI at rest reaches 400-600 conv. units in patients with constant voltage of regulation systems; and reaches up to 1000-1500 units in patients with heart stroke and myocardial infarction.

RRNN - mean duration of RR intervals and the inverse of this indicator - the average number of heart rate (HR). Indicator RRNN reflects the end result of numerous regulatory influences on the sinus rhythm of the existing balance between parasympathetic and sympathetic divisions of the autonomic nervous system. SDNN (standard deviation of the NN interval) is the standard deviation of the values of normal RR-intervals. SDNN is an integral indicator of the heart rate variability in general, and depends on the parasympathetic and sympathetic systems impact on the sinus node. Increasing or decreasing this indicator demonstrates a shift in autonomic balance towards the predominance of one of the parts. RMSSD - standard deviation of the RR intervals differences from their arithmetic mean, the index of the vegetative regulation parasympathetic element activity. The normal values of this index are within 20-50 milliseconds. NN50 - number of pairs of successive RR intervals differing by more than 50 ms. pNN50 - percentage of RR on the number of all analyzing cardio intervals.

Mode (Mo) - is the most frequent value of RR intervals. It points to the dominant level of the sinus node functioning. The mode is minimal in sympathicotone, and it is maximal at vagotone. In normal, the value of the mode ranges from 0.7 to 0.9.

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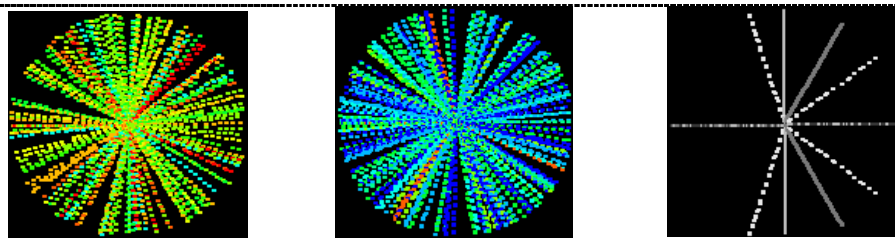
Mode amplitude (AMO) - the ratio of RR interval with a value equal to the total number of RR - intervals. This indicator reflects the degree of rigidity of rhythm. Its normal values are 30-50%. Increased AMO would indicate the predominance of sympathetic effects on sinus node and significant rigidity of rhythm. When vagotone this indicator tends to decrease. Results of statistical analysis, histogram, spectral analysis of heart rate variability (HRV) are presented in accordance with "Standards of measurement, physiological interpretation and clinical use of heart rate variability," developed by a group of experts from the European Association of Cardiology and the North American Society of Pacing and Electrophysiology (1996).

FIGURE 1. EXAMPLES OF PHASE SECTORS

FIGURE 2. EXAMPLES OF SPLINE MAPS



According to their results, researches on the grounds of SDNN indicators developed regulations that allow understanding of the autonomic balance of the body (Dicheskul, 2001). In normal, it ranges from 30-50.

Dynamic analysis of brain rhythms is made through neurodynamic study of heart rhythmograms and calculating ranges of delta, theta, alpha, beta1 and beta2 rhythms (Golofeevsky et al., 2001).

"Fast" or nervous component of adaptation is reflected in a set of spline maps; it conditions formation cellular structure of the brain by ensembles of neurons. Spline maps are generated by interpolating amplitude values of the brain basic rhythms relative to each other; they represent a transition matrix of the basic rhythms in the functional spaces of the brain. Colours correspond to different rhythms, and the breadth of sectors is defined by the modulation index of the spectrum frequency components. The maximum colour saturation corresponds to normal activity. The level of saturation decreases sharply when functional and pathological disorders are available in humans (Figure 1).

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"Slow" or the metabolic component of adaptation is reflected in the phase portrait of the rhythms of the brain. Colours correspond to different rhythms, and the breadth of sectors is defined by the modulation index of the spectrum frequency components (Figure 2).

Results

To clarify the correspondence of HRV to specific states of the vegetative tone (vagotone, normotone, and sympathicotone), the healthy people and patients with hypothyroidism, regardless to the TSH levels, were grouped according to the tension index (TI). Among patients with hypothyroidism there were 6 ones with normotone (TI 30-100 s.u.), among healthy people - 12 (TI more than 100 s.u.). There were 36 patients with hypothyroidism and 4 healthy persons were in the group with sympathicotone. In the group with vagotone (MI less than 30 s.u.) there were 14 healthy persons and no patients with hypothyroidism.

TABLE 1. RATE OF CHANGES OF THE AUTONOMIC NERVOUS SYSTEM ACTIVITY AMONG THE PATIENTS WITH HYPOTHYROIDISM AND HEALTHY PERSONS (P ± P%)

Indicators of vegetal tone	N	P±p, %	N	P±p, %	P
	HT patients (42)		Healthy persons (30)		
Normotone	6	14.3± 2.7%	12	40± 8.9%	<0.001
Sympathicotone	36	85.7± 5.4%	4	13.3± 5.8%	<0.001
Vagotone	0	0±0%	14	46.7± 9.1%	<0.001

TABLE 2. PERFORMANCE ANALYSIS OF VARIANCE OF HEART RHYTHMS OF PATIENTS WITH HYPOTHYROIDISM AND HEALTHY SUBJECTS (M ± M)

Group, Indicators	Patients with hypothyroidism M ± m	Healthy individuals M ± m	P
IVB	503.7±83.8	80.13 ± 0.15	< 0.01
VRI	0.17±0.001	0.37 ±0.006	< 0.05
RPAI	64.9±4.3	39.17± 2.52	<0.05
TI, s.u.	333.3±68.9	72.15 ± 6.31	< 0.001
RRNN, ms	866.3±29.3	734.2 ± 9.56	>0.05
SDNN, ms	27.9±3.1	60.6 ± 0.31	<0.05
RMSSD, ms	20.9±1.9	76.8 ±0.23	<0.01
NN50%	14.7±6.3	93.17 ± 0.12	<0.001
Mo, мс	852.2±27.6	881 ±17.3	>0.05
AMo %	52.7±2.4	23.21 ±1.81	<0.05
NHR, beats/min	74.2±2.4 (42-90)	68.5± 3.2 (68-78)	>0.05
VB	143.9±8.1	329.22 ± 3.57	<0.05
HRV - index	7.4±0.4	17.1 ±0.1	<0.05
LF/ HF	2.5±0.4	1.1 ±0.1	>0.05

According to the Table 1 it is obvious that among patients with hypothyroidism there were significantly more frequent ones with sympathicotone as compared to those with normotone and vagotone (P <0.001). People with normotone and vagotone are the most often encountered among healthy people. If compare patients with hypothyroidism and healthy people for each group of the autonomic nervous system tone, then cases with normotone and vagotone are significantly lower, sympathicotonic cases are considerably higher among patients (P<0.001). The average values of HRV parameters depending on the value of the TI in patients with hypothyroidism compared with healthy persons are presented in Table 2.

It is clear that performance indicators differ significantly between groups, except for the mode (Mo) and the average heart rate. In the patients with hypothyroidism the average heart rate 74.2±2.4 beats/min. and ranged from 42 to 90 beats/min. Significant increase in performance of

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AMO, RPAI, relationship LF/HF and TI indicates on the predominance of sympathetic division of ANS.

Patients with hypothyroidism were found with a significant decline in RMSSD and pNN50 compared to the healthy people ($P<0.05$): this indicates on weakening of the parasympathetic ANS influence. Increase of AMO in patients with hypothyroidism also shows a more pronounced effect of sympathetic part of the SPA. Index CDF is less than 0.25 that indicates on the predominance of parasympathetic ANS ($P> 0.05$).

Thus, in hypothyroidism it is revealed a significant change in the autonomic nervous system with predominance of the sympathetic division, while the weakening parasympathetic ANS as it is evidenced by the reduction of the CDF. This confirms what is known on the violation of both ANS with a predominance of any department for somatic diseases. Violations of the autonomic nervous system, as a result of changes in the parameters variation of heart rhythms in hypothyroidism, are possibly conditioned by violations of mutual interaction of the hypothalamus and thyroid gland.

Conclusion

The method of variation of heart rhythms reflects the state of the main regulatory body systems such as hemodynamic, autonomic, and endocrine; this characterizes the functional state of the organism. The sharp rise in the basic parameters of HRV marker of poor flow indicates on depletion of the compensatory capacity in patients with hypothyroidism. Revealed significant excess of MI in patients with hypothyroidism testifies on distortion of functions of the cardiovascular system, and requires correction in the treatment of these complications. Increased HRV and AMO, and reduction of RMSD, SDNN, pNN50 in patients with hypothyroidism show imbalance of autonomic nervous system with predominance of the sympathetic on the background of weakening parasympathetic part of ANS. This method of research can be used to stratify the risk of cardiovascular complications in patients with hypothyroidism.

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